

1       PROGRAMMABLE THERMOSTAT SYSTEM EMPLOYING A  
2       TOUCH SCREEN UNIT FOR INTUITIVE INTERACTIVE  
3       INTERFACE WITH A USER

4   Field of the Invention

5       This invention relates to the art of thermostats and, more particularly,  
6   to a programmable thermostat system incorporating an integrated liquid  
7   crystal display/touch pad unit, constituting a touch screen, for interactive  
8   intuitive interface with a user to facilitate programming the thermostat  
9   system.

10   Background of the Invention

11       Thermostats have been used for many years as a temperature sensitive  
12   switch which controls heating and/or cooling equipment for conditioning a  
13   space in which the thermostat, or a temperature sensor connected to the  
14   thermostat, is placed. In the well known manner, a simple thermostat can be  
15   adjusted to establish a temperature set point such that, when the temperature  
16   in the conditioned space reaches the set point, the thermostat interacts with  
17   the heating and/or/cooling equipment to take suitable action to heat or cool  
18   the conditioned space as may be appropriate for the season.

1 Modern thermostat systems, which take advantage of the ongoing rapid  
2 advances in electronic technology and circuit integration, have many features  
3 which provide more precise supervision of the heating and/or cooling  
4 equipment to achieve more economical and more comfortable management of  
5 the temperature of a conditioned space. Many modern thermostat systems  
6 include a real time clock, a memory and a data processor to run a process  
7 control program stored in the memory to accurately measure the temperature  
8 of a temperature sensor disposed in the conditioned space and to send control  
9 signals to the heating and/or cooling equipment to closely control the  
10 temperature of the conditioned space. The use of programmed thermostat  
11 systems permit anticipating and minimizing hysteresis or overshoot of the  
12 temperature in the conditioned space. In addition, the program can specify  
13 different set points at different times of the day and week and may also  
14 include a "vacation" mode which employs different set points when the  
15 conditioned space is not occupied for an extended period.

16 Many modern thermostat systems are programmable by a user.  
17 Typically, prior art programmable thermostat system employ a tactile touch  
18 pad with various fixed position buttons to be touched in a precise sequence to  
19 program set points (which may vary with the day of the week) for  
20 programmable time periods which may include a vacation mode. The

1 programming sequence may be followed on a separate display, typically a  
2 liquid crystal display.

3 There is a fundamental problem with the prior art programmable  
4 thermostat systems: they are difficult to program and some users are unable  
5 to successfully program them. This is because the user interfaces which have  
6 been employed in prior art programmable interfaces are not highly intuitive.  
7 Programmable thermostat systems have incorporated fixed position buttons,  
8 at least some of which have multi-functions depending upon the point at  
9 which a user has reached in the programming process. The user must usually  
10 refer to and attempt to decipher a programming manual (which is often  
11 difficult for the average user to readily understand) as the programming  
12 proceeds. But, the programming process is so complex to follow while trying  
13 to remember the instructions that many users give up, and the full capabilities  
14 of the thermostat system cannot be utilized.

15 The present invention addresses this problem fundamentally and solves  
16 the problem in an efficient and highly effective manner.

### 17 Summary of the Invention

18 A programmable thermostat system for controlling space conditioning  
19 equipment according to the invention includes: a transparent touch pad  
20 juxtaposed over a liquid crystal display to constitute a touch screen for

1 interactive interface with a user; a temperature sensor for providing an  
2 electrical signal indicative of the temperature of a conditioned space; and a  
3 processor including: a central processing unit; a real time clock; a memory  
4 coupled to the central processing unit for storing program and data  
5 information; and an input/output unit coupled between the processor and said  
6 touch screen for carrying out information transfer therebetween. A program  
7 stored in the memory directs the central processing unit to communicate  
8 through the input/output unit to selectively: establish on the liquid crystal  
9 display a representation of at least one button at a predetermined XY  
10 position; read the same XY position on the touch pad to determine if the  
11 "button" has been touched; and if the button has been touched, perform a  
12 predetermined action such as moving to a different menu or changing  
13 operating criteria. Preferably, an alphanumeric message explaining the  
14 function of the button is also displayed, and icon indicators may be employed  
15 to unmistakably associate a message with a button. Different menus can  
16 place the buttons and messages in various positions on the touch screen to  
17 facilitate intuitive programming.

#### 18 Description of the Drawing

19 The subject matter of the invention is particularly pointed out and  
20 distinctly claimed in the concluding portion of the specification. The

1 invention, however, both as to organization and method of operation, may  
2 best be understood by reference to the following description taken in  
3 conjunction with the subjoined claims and the accompanying drawing of  
4 which:

5 FIG. 1 is a block diagram of a space conditioning system incorporating  
6 a thermostat system employing the present invention;

7 FIG. 2 is an exploded view of an exemplary touch screen which is a  
8 key component of the thermostat system;

9 FIG. 3 is an exemplary pictorial of a high level interactive interface  
10 displayed on the touch screen during normal operation;

11 FIG. 4 is an exemplary pictorial of an intermediate level interactive  
12 interface displayed on the touch screen;

13 FIG. 5 is an exemplary pictorial of a low level interactive interface  
14 displayed on the touch screen;

15 FIG. 6 is an exemplary pictorial of another low level interactive  
16 interface displayed on the touch screen;

17 FIG. 7 is an exemplary pictorial of another low level interactive  
18 interface displayed on the touch screen;

19 FIG. 8 is an exemplary pictorial of another low level interactive  
20 interface displayed on the touch screen;

FIG. 9 is an exemplary pictorial of another low level interactive interface displayed on the touch screen;

FIG. 10 is an exemplary pictorial of another low level interactive interface displayed on the touch screen;

FIG. 11 is an exemplary pictorial of another high level interactive interface displayed on the touch screen;

FIG. 12 is an exemplary pictorial of another low level interactive interface displayed on the touch screen; and

FIG. 13 is a high level process flow chart alternatively describing a principal feature of the operation of the invention.

#### Description of the Preferred Embodiment(s)

Referring first to FIG. 1, a thermostat system includes a processor 1, a touch screen 2 and a temperature sensor 5 which is disposed in a conditioned space 4. It will be understood that the processor 1 and the touch screen 2 are typically situated in a common housing (not shown). The sensor 5 may also be situated in the common housing or remotely as shown, all as very well known in the art. The common housing is usually, but not necessarily, placed in the conditioned space 4. Thus, those skilled in the art will understand that the block diagram of FIG. 1 is very general in order to best explain the invention.

1       The processor 1 includes a central processing unit (CPU) 9 in  
2       communication with a memory 8 for storing data and program information  
3       and also, via an input/output unit (I/O unit) 10, a touch pad 11 and a liquid  
4       crystal display (LCD) 12 which constitute the touch screen 2. The memory 8  
5       may include a read-only part which is factory-programmed and a random-  
6       access part which stores data subject to change during operation. A settable  
7       real time clock 13 is used to keep time in the thermostat system to facilitate  
8       diverse operations, such as different temperature set points (desired  
9       temperatures), during different periods of the day cycle. An analog-to-digital  
10      converter 27 (which may not be required in all systems) serves to convert any  
11      analog information received by the I/O unit 10 to digital information which is  
12      suitable for use by the CPU 9. The thermostat system may be suitably  
13      powered by a battery (not shown) and/or from equipment to which is  
14      connected.

15      Temperature information from the sensor 5 and output signals to a  
16      space conditioning (heating and/or cooling) unit 3 pass through the I/O unit  
17      10 under control of the CPU 9. Those skilled in the art will understand that if  
18      the correspondents external to the processor 1 communicating with the CPU  
19      9 are all digital in nature (e.g., if the temperature sensor 5 incorporates its  
20      own analog-to-digital converter and sends a digital representation of

1 temperature to the processor 1), then the I/O unit 10 may only constitute  
2 simple switching circuits. The liquid crystal display may optionally be  
3 backlit by any suitable means (not shown).

4 Thus, in the usual manner during normal operation, the temperature  
5 sensor 5 sends an electrical signal (e.g., if the sensor 5 is a simple thermistor,  
6 a resistance value; several types of temperature sensors are widely used)  
7 representative of the temperature within the conditioned space 4 which the  
8 processor can compare against a previously entered set point to determine if  
9 control signals need to be sent to the space conditioning equipment 3. For  
10 example, if the temperature in the conditioned space 4 is found to be too low  
11 when operation is in the heating mode, the processor 1 signals the spaced  
12 conditioning equipment 3 circulate, through ducts 6, 7, air from/to the  
13 conditioned space 4 which is heated by the space conditioning equipment  
14 before return to the conditioned space. This heating phase continues until the  
15 sensor 5 indicates that the space is now too hot (or approaching too hot) with  
16 reference to the set point such that the processor 1 sends signal(s) to the  
17 space conditioning equipment 3 to cease the heating function, all as very well  
18 known in the art. In a cooling mode, a counterpart procedure is followed.  
19 Those skilled in the art will understand that the control process typically  
20 includes such refinements as anticipation, hysteresis accommodation, fan



1 control, etc. which are acknowledged, but are not directly relevant to the  
2 invention.

3 It may be noted that integrated circuit chips including all the processor  
4 components with all the necessary interface conditioning circuits are  
5 available off-the-shelf and are under constant refinement for increased power.  
6 The subject invention only requires the capabilities of such a processor, and  
7 off-the-shelf integrated circuit processor chips may be used to advantage in  
8 the subject thermostat system.

9 Thermostat systems may be user programmable or non-user  
10 programmable. The present invention relates to programmable thermostat  
11 systems in which, in the prior art, programming steps have been entered  
12 using a "tactile" touch pad while observing a display which may be a liquid  
13 crystal display or some other display type. The drawbacks of the prior art  
14 interactive components have been discussed above. The present invention  
15 employs a different type of thermostat user interface; viz., the touch screen 2,  
16 in which the touch pad 11 and LCD 12 are integrated and coordinated as will  
17 be discussed below and which, in conjunction with the processor 1, provides  
18 a programmable thermostat system which is very much easier to program  
19 than in the prior art.

1 Referring now to FIG. 2, there is shown an exploded view of an  
2 exemplary touch screen 2 according to the invention. The structure shown in  
3 FIG. 2 is exemplary only, and several other structures capable of performing  
4 the same functions will be discussed below.

5 A transparent touch pad 11, constituting generally planar layers 22-26,  
6 is juxtaposed over a flat panel LCD 12 with RF shield layer 21 interposed.  
7 The layers of the touch screen 11 (a relatively simple “four-wire” analog  
8 resistive type in the example) are respectively: a transparent glass substrate  
9 22; a transparent film 23 for the X-plane; insulating spacer microspheres; a  
10 transparent film 25 for the Y-plane; and an transparent outer hard coating 26.  
11 In the example, the facing surfaces of the X-plane film 23 and the Y-plane  
12 film 25 are coated with indium tin oxide (ITO), and they are normally  
13 prevented from making electrical contact by the microspheres. Contact  
14 between the X-plane film 23 and the Y-plane film 25 is made by mechanical  
15 pressure from, for example, a finger touch. When contact occurs, the  
16 coordinates are determined from the resistance value that is proportional to  
17 the location of the touch. The X-plane resistance value is coupled to the I/O  
18 unit 10 by conductors 28, and the Y-plane resistance value is transferred by  
19 the conductors 29. In the I/O unit 10, the resistance values for the XY

1 position of a touch are converted to digital values by the A/D converter 27  
2 for use by the processor.

3 It should be understood that the touch pad 11 shown in FIG. 2 and  
4 described immediately above is only one of several types of transparent touch  
5 screens which can be juxtaposed with the LCD 12 to constitute the touch  
6 screen 2 (FIG. 1). The commercially available types of transparent touch  
7 pads contemplated for alternate use in the invention at the current state-of-  
8 the-art are: resistive analog (4-wire as shown, 5-wire and 8-wire); resistive  
9 matrix; capacitive matrix; acoustic surface wave; near field imaging;  
10 capacitive overlay; and infrared scanning. Future types of touch screens may  
11 be expected to be appropriate for use in this invention.

12 Consider now the advantages of employing the touch screen 2 in the  
13 subject thermostat system in conjunction with the following discussion of  
14 various exemplary displays which can be presented on the touch screen 2 and  
15 which invite interaction by a user. FIG. 3 shows the touch screen displaying  
16 normal operating information and also representations of buttons 30, 31 and  
17 32. The "buttons" 30, 31, 32 are generated by the processor 1 at  
18 predetermined convenient and intuitive positions on the touch screen 2 which  
19 have been stored in the memory. If one of the buttons is touched, the XY  
20 information describing the touch point is sent to the processor which

1 recognizes that the position at which the touch screen has been touched is  
2 juxtaposed with that particular button and responds by carrying out some  
3 predetermined associated action. For example, if the button 30, labeled  
4 “DN”, is touched, that fact is sensed by the processor which drops the current  
5 set point from, say, 72°F to 71°F. The set point can similarly be raised by  
6 touching the button 31 which is labeled “UP”. Touching the touch screen 2  
7 outside the button positions does not affect operation.

8 Attention is directed, in FIG. 3, to the alphanumeric message to the left  
9 of the button 32 labeled “PGM”. A user is invited, if desired, to touch the  
10 “PGM” button 32 to change the current time, time periods and/or  
11 temperatures or to start/stop vacation mode. (These actions are exemplary  
12 only; for example, “select heat/cool mode” and other such actions can be  
13 included as appropriate for a particular thermostat system.) If the button 32  
14 is touched, a menu such as that shown in FIG. 4 replaces (using display  
15 information prestored in memory 8) the display shown in FIG. 3.

16 The intermediate level display of FIG. 4 invites a user to select one of  
17 the four available actions which are individually explained by the  
18 corresponding four alphanumeric messages. FIG. 4, with reference to FIG. 3,  
19 illustrates a particularly significant feature of the invention. The four choice  
20 buttons “PRD” 33, “TEMP” 34, “TIME” 35 and “VAC” 36, are vertically

1 arrayed toward the right of the touch screen 2 at predetermined convenient  
2 positions from display information stored in the memory 8. But, if these  
3 positions are compared to the positions of the buttons 30, 31, 32 in FIG. 3, it  
4 will be seen that they would “interfere” physically if conventional tactile  
5 buttons were used. With the present invention, however, the positions of  
6 buttons on different menus can be placed wherever it is most intuitive and  
7 convenient for the present selection of operations. This is impossible to  
8 achieve with the prior art thermostat systems and is a prime factor in the ease  
9 of programming enjoyed by the use of the subject thermostat system.

10 FIG. 4 also shows another, optional, feature of the invention. Because  
11 each menu can be displayed in any manner a system programmer wishes, icon  
12 indicators, such as the arrows 33A, 34A, 35A, 36A, can be included to  
13 further assist a user to select and touch the correct button to successfully  
14 move to the next menu or make other selections with confidence.

15 Accordingly, if a user wishes, from the menu shown in FIG. 4, to  
16 change the period times, he is unmistakably directed to touch the “PRD”  
17 button 33. In response, the processor 1 causes a lower level menu such as  
18 that shown in FIG. 5 to be displayed to begin setting the discrete periods  
19 during which different temperature set points may be established. Assuming  
20 in the example that four periods are available, a user may set the beginning of

1 “Period 1” to any time of day by using the “UP” button 38A and/or the “DN”  
2 button 39A until, say, 11:00 PM is shown in the prominent time display to  
3 the left of the buttons 38A, 39A. The user is prompted to, by the  
4 alphanumeric message above the “NEXT” button 37, to touch the “NEXT”  
5 button 37 after the beginning time for “Period 1” has been established.  
6 Touching the NEXT button 37 causes the processor to present the slightly  
7 different display shown in FIG. 6 from which the ending time for “Period 1”  
8 may be set. This step, in the example, also establishes the beginning time for  
9 “Period 2”. After setting the ending time for “Period 1” by selectively  
10 touching the “UP” button 38B and/or the “DN” button 39B until, say, 6:30  
11 AM is reached, the user touches the “NEXT” button 40 to bring up an almost  
12 identical display (not shown) for setting the ending time for “PERIOD 2” to,  
13 say, 4:30 PM which also sets the beginning time for “Period 3” and then  
14 proceeds to the screen shown in FIG. 7. From the menu shown in FIG. 7, the  
15 user sets, using buttons 38D, 39D, the ending time, say 9:30 PM, for “Period  
16 3” which also establishes the beginning time for “Period 4”. (The ending  
17 time for “Period 4” is the same as the already entered beginning time for  
18 “Period 1”.) After this information as been entered, the user is directed to  
19 touch “RUN” button 42 which returns the thermostat system to normal  
20 operation and again brings up the menu shown in FIG. 3.

1 If a user wishes to change the temperature set point in any of the  
2 exemplary four periods, the “PGM” button 32 is touched to move to the menu  
3 of FIG. 4 and the “TEMP” button 34 is touched as urged by the relevant  
4 alphanumeric message and, if provided, the icon indicator arrow 34A. The  
5 menu shown in FIG. 8 appears in response and in which the current set point  
6 for “Period 1”, 68°F in the example, is prominently shown. The user touches  
7 the “UP” button 51A and/or the “Down” button 52A as necessary to set a  
8 new set point for this period and then touches the “NEXT” button 61 as  
9 invited by the alphanumeric message presented above that button. Almost  
10 identical (only the alphanumeric message being suitably revised) menus (not  
11 shown) successively appear for making the corresponding adjustments to the  
12 set points for “Period 2” and “Period 3” after which the menu shown in FIG.  
13 9 appears. After the set point is adjusted for “Period 4” by touching the  
14 buttons 54A, 54B as necessary, the user is invited to touch the “RUN” button  
15 64 which will again return the system to normal operation with the menu  
16 shown in FIG. 3 presented.

17 If a user wishes to set the present time, the “PGM” button 32 is  
18 touched (FIG. 3) and the “TIME” button 35 (FIG. 4) is touched which causes  
19 the processor 1 to establish the menu shown in FIG. 10 on the touch screen 2.  
20 The prominently displayed current time is adjusted by suitably touching the

1 “UP” button 71 and/or the “DN” button 72 until the correct current time is  
2 displayed. The user is then invited, by the alphanumeric message shown, to  
3 touch the “RUN” button 70 to return to normal operation with the display of  
4 FIG. 3 which will now show the correct current time.

5 Some programmable thermostat systems incorporate a vacation mode  
6 in which different temperature set points for the several periods are desirable  
7 in order to economize on the energy costs associated with conditioning the  
8 temporarily unoccupied space 4. From the successive menus shown in FIGs.  
9 3 and 4, the “PGM” button 32 and the “VAC” button 36 are touched to direct  
10 the processor to establish the menu shown in FIG. 11 in which the user is  
11 invited to touch the “VACATION MODE” button 80. This action directs the  
12 processor 1 to display the menu shown in FIG. 12 in which a message invites  
13 the user to touch the “PGM” button 32V in order to set up the vacation mode  
14 set point temperatures for the several periods. This procedure is performed as  
15 discussed above, but the processor 1 is aware that vacation mode temperature  
16 set points are being entered and does not change the normal mode set points.  
17 After the vacation mode set points have been set (the last from the menu  
18 shown in FIG. 9) the menu shown in FIG. 12 is displayed during the vacation  
19 period.



1 Still referring to FIG. 12, when the space 2 is again to be occupied, a  
2 user can successively touch the "PGM" button 32V and the "VAC" button 35  
3 (FIG. 4) from which the processor 1 will establish the menu shown in FIG. 13  
4 on the touch screen 2. The user is invited to touch the "NORMAL MODE"  
5 button 81 by the alphanumeric message, and the processor 1 will respond by  
6 restoring normal operation, with the correct previously established normal  
7 temperature set points, and return to the menu shown in FIG. 3.

8 FIG. 14 is a process flow chart alternatively presenting fundamental  
9 aspects of the invention. By the use of a touch screen constituting a  
10 transparent touch pad juxtaposed over a liquid crystal display in a  
11 programmable thermostat system, programming is greatly simplified by the  
12 fact that various menus can have ergonomically variously placed "buttons"  
13 along with intuitively variously placed messages associated with each button.

14 It is important to note again that the exemplary displays/menus  
15 discussed above are merely to clearly present the invention. Commercial  
16 embodiments of the invention may incorporate more fully designed and  
17 elegant refinements in various configurations in a plurality of models.

18 Thus, while the principles of the invention have now been made clear  
19 in an illustrative embodiment, there will be immediately obvious to those  
20 skilled in the art many modifications of structure, arrangements, proportions,

- 1 the elements, materials, and components, used in the practice of the invention
- 2 which are particularly adapted for specific environments and operating
- 3 requirements without departing from those principles.